N87-20927

Magnetogram and Soft X-ray Comparisons of XBP and ER

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Introduction

The potential importance of the smallest emerging flux regions on the Sun has been discussed in numerous publications since the early 70's when the large number of such regions first became evident (Harvey, Harvey and Martin 1975; Golub *et al.* 1974; Golub *et al.* 1977; K. Harvey 1985). The association between the objects seen in ground-based data, such as high resolution magnetograms or Hα and soft x-ray data has produced results which are often contradictory: the overlap in the two data sets is great enough as to leave no doubt that the same objects are *in general* seen by both techniques. However, there are significant numbers of cases in which a region is seen by one method but not by the other, and these discrepancies have never been fully explored.

Problems of this sort take on greater significance when we consider the role that small emerging flux regions assume in comparison to the larger active regions. A decade of work on this subject may be summed up as follows: x-ray studies indicate that bright points (XBP) represent the short-lifetime portion of a distribution which is continuous with active regions. The large number of XBP makes them the largest contributor to the total magnetic flux emergence from the Solar interior; moreover, XBP vary out of phase with the larger active regions, in such a way as to nearly conserve the total quantity of magnetic flux throughout the cycle. Similar studies done using magnetogram data offer very different results - ephemeral regions (ER) vary in phase with the cycle and are suggested to be primarily surface phenomena. XBP seem to be associated with chance encounters between opposite polarity network flux, arising from mixed polarity areas of diffusing fields from previously emerged active regions.

These studies are contradictory and the potential implications are too great to be ignored. In the hope of resolving the present impasse we have assembled as much *simultaneous* soft x-ray and magnetogram data as possible in order to test directly the above suggestions. These data have been obtained over the past decade during rocket flights of a soft x-ray telescope, with (weather permitting) same-day ground based observations.

The Data

Data from four flights of the AS&E x-ray rocket payload were used, along with the available magnetogram and He 10830λ observations. Dates and times are listed in Table 1. We also list the number of x-ray and magnetic features seen in each dataset; these will be explained in the next section. In the present study we have used only the x-ray and magnetic field data - the He observations will be included in the next stage of this work.

The x-ray features were selected by examination of enlarged transparencies, as described in our earlier papers (e.g. Golub *et al.* 1977). The magnetogram analysis entailed a somewhat more elaborate procedure than has been used in the past, with bipoles divided into several categories; ephemeral regions (i.e. emerging flux), chance encounters of opposite polarity field, and longer-lived bipoles visible on at least two days. such identification was performed on the first magnetogram of the day and, if additional observations were available, subsequent magnetograms were compared with the first one in order to identify developing structures, encounters, and disappearing flux.

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Table 1. Dates of Simultaneous X-ray and Magnetogram Data

Date	Type of Data	Time(s) [UT]	Feature	Number
13 Feb. 1981	X-ray	1916	XBP	5
	Magn.	1507	Encounter	19
	10830λ	1638	ER	22
			Bipole	11
16 Nov. 1979	X-ray	1703	XBP	14
	Magn.	1543, 1743, 1828,	Encounter	11
		1917, 2007, 2100.	ER	25
	10830λ	1647	Bipole	10
16 Sept. 1976	X-ray	1803	XBP	90
	Magn.	1533	Encounter	31
	10830λ	1841	ER	33
			Bipole	10
27 June 1974	X-ray	1948	XBP	58
	Magn.	1508, 1854	Encounter	30
	10830λ	1605, 1657, 1740	ER	17
		1804.	Bipole	6

Results

In view of the contradictory claims which have appeared in recent years, we anticipated that this more elaborate separation of magnetic features into emerging and "reconnecting" regions would clarify the situation. However, we find as the main result of the present study, that the separation makes very little difference. Our results are summarized in Table 1, which shows the number of each type of feature found in the x-ray and magnetogram images, the latter separated into the three classes mentioned above.

The comparison with x-ray data was done by first identifying the x-ray bright points, then correlating the XBP's with the three classes of magnetogram features which had been previously identified independent of the x-ray data. The major result of the comparison is that the three subgroups "encounters", "ephemeral regions" and "bipoles" provide an ordering having increasing probability of being seen in x-rays. That is, the reconnecting or chance encounters are less likely to coincide with an XBP than are the ephemeral regions, which are in turn less likely to overlap than are the old bipoles. The chance (averaged over the four observation days) of seeing an x-ray feature where a magnetic feature has been identified is:

encounters: 21%
ephemeral regions: 29%
bipoles: 50%

Note that these percentages represent identifications made from the magnetograms to the x-ray data. We have not attempted identifications in the other direction. However, the number of x-ray features seen in 1976 is greater than the number of magnetic features, in 1974 it is about the same and in 1979 and 1981 it is significantly lower.

We conclude that the separation of magnetic features into chance encounters and emerging flux makes some difference in the overlap with x-ray bright points, although the effect is not overwhelming. There is a slight tendency for a smaller fraction of the "encounters" to be visible in the corona. The difference in solar cycle dependence between XBP and ER is *not* explainable in terms of the results of this study.

This work was supported at SAO by NASA Grant NAGW-112.

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